LCA of Nanotechnological Products

What's the issue?

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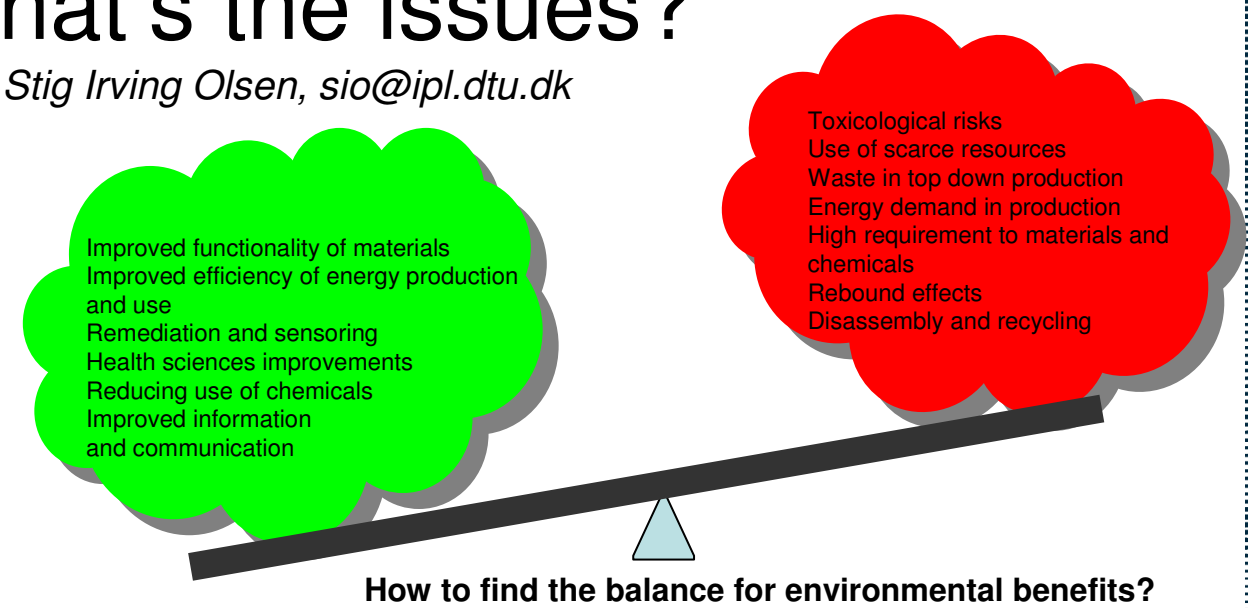
Nanotechnology

An enabling technology –
Meaning it provides the possibilities to see and manipulate nanosized structures

Great potential for "smart" multifunctional and high-performance products for innumerable commercial and industrial applications.

Sector/Application	
Automotive	**Chemical**
Lightweight construction; Catalysts, Painting; Tires; Sensors; Windshield and body coatings	Fillers for paints; Composite materials; Impregnation of papers; Adhesives; Magnetic fluids
Construction	**Cosmetics**
Materials; Insulation; Flame retardants; Surface coatings; Mortar	Sunscreen; Lipsticks; Skin creams; Toothpaste
Electronics	**Energy**
Displays; Data memory; Laser diodes; Fiber optics; Optical switches; Filters; Conductive, antistatic coatings	Lighting; Fuel cells; Solar cells; Batteries; Capacitors
Engineering	**Environmental**
Protective coatings for tools, machines; Lubricant-free bearings	Environmental monitoring; Soil and groundwater remediation; Toxic exposure sensors; Fuel changing catalysts; Green chemistry
Food and Drink	**Household**
Packaging; Storage life sensors; Additives; Juice clarifiers	Ceramic coatings for irons; Odor removers; Cleaners for glass, ceramics, metals
Medicine	**Sports**
Drug delivery systems; Contrast medium; Rapid testing systems; Prostheses and implants; Antimicrobial agents; In-body diagnostic systems	Ski wax; Tennis rackets; Golf clubs; Tennis balls; Antifouling coatings for boats; Antifogging coatings for glasses, goggles
Textiles	**Warfare**
Surface coatings; "Smart" clothes (anti-wrinkle, stain resistant, temperature controlled)	Neutralization materials for chemical weapons

(Lekas, 2005)



How to find the balance for environmental benefits?

Uncertainties!

Production processes

Ultra clean room requirements?
Material specification, e.g.
- •high purity chemicals
- •high quality and purity bulk materials

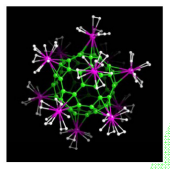
Data estimation routines necessary (initially)
Anticipated high energy usage, and large waste production (in top down production)
Inclusion of capital equipment?

PVD
CVD
Sol gel
Flame assisted deposition
Flame hydrolysis
Molecular imprinting
Litography
Spin coating
Etc.

Data is missing!

Nano products

New functionalities
Additional benefits to technical function
Definition of functional unit
Rebound effects?



Three-dimensional Scandium (pink) C_{60} (green) complex. Dillon et al., 2006. Mater. Res. Soc. Symp. Proc. Vol. 895

Raw materials

Increased usage of rare elements
Depletion of scarce resources?
Impact assessment of resources required
Data for Mining!

?

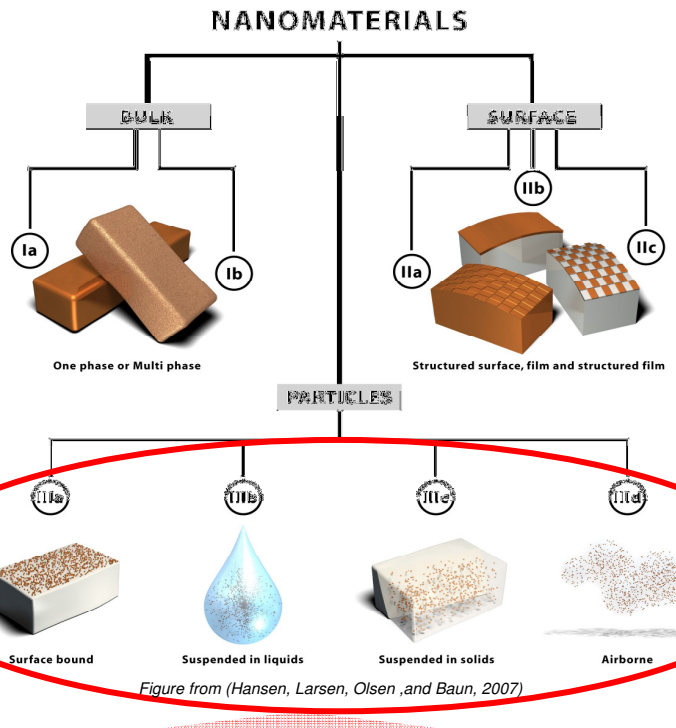


Figure from (Hansen, Larsen, Olsen ,and Baun, 2007)

Inventory issues for Nanoparticles

Definition, nomenclature and classification
Emission paths and volume
Measurement and characterisation techniques

Disposal

Difficulties in disassembly and recycling
Waste related problems with nanoparticles
Knowledge about behaviour of "nano" waste

Case studies needed!

Life Cycle Impact Assessment of nanoparticles

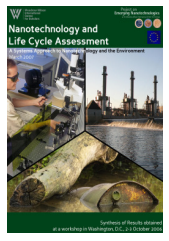
Fate and transport?
Uptake and mobility in organisms
Toxicological mechanisms?
Dose-response relationship?

Need for simplified sensitivity assessments or worst case scenarios?

Determining parameters?
- •Size (surface area, size distribution)
- •Chemical composition (purity, crystallinity, electronic properties etc.)
- •Surface structure (surface reactivity, surface groups, coating etc.)
- •Solubility
- •Shape
- •Aggregation

Information flow and cooperation with risk assessment community needed!

A joint US –EU workshop identified a number of LCA and nanotechnology related issues and came up with recommendations for the further work (Klöpffer et al., 2007)



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